

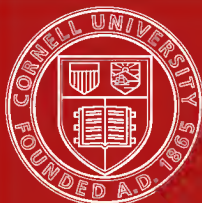
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THE
CLOUDS AND FOGS
OF SAN FRANCISCO



The Grain

PAINTED BY ARTHUR F. MATHEWS

"From Ocean's breast to the expectant fields I come"

THE
CLOUDS AND FOGS
OF SAN FRANCISCO

BY
ALEXANDER McADIE



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A. M. ROBERTSON
MCMXII

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SAN FRANCISCO

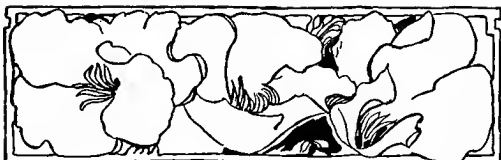
TO
M. R. B. M.

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THE CLOUDS.

NURSLINGS of the Sky”
the clouds have been
called. The phrase is
Shelley’s but the thought
is as old as mankind.

For when the first man woke to
consciousness of beauty in the life
around him, looking upward he
found there also forms of grace.
“Children of the Sky” they must
have seemed to him. Perhaps in
the beginning he doubted their
harmlessness and watched with
some trepidation the cloud shadows,
at times lingering as if to caress the
hills and again passing on more
rapidly than swiftest birds. Then
reassured and bolder grown, he

2 *THE CLOUDS AND FOGS*

walked about unmindful of the sky creatures, nor did he heed them save when at sunrise and again at close of day, his barbaric indifference yielded to the power of beauty. Compelled then to notice and respect, his fancy peopled the sky with beings mysterious as the clouds themselves. In that order of existence so different from his own, his untutored mind, ere long

“ *Saw God in clouds and heard Him
in the wind.*”

It is a far cry from primitive man to the out-of-doors man of today: yet if the truth be told there is no great disparity in their knowledge of clouds. It may hurt our pride to confess it, but most of us, mountaineers and mariners included, are only nephelolaters, cloud admirers and nothing more. Few read in a cloud a story of birth, growth and dissolu-

tion, a sequence not without significance to men. In the life history of each nomad of the sky there is a wonder tale of forces operating at various levels with varying intensities. Each delicately poised mass illustrates physical processes, which harnessed in the steam engine have determined the destiny of nations. So much do we seem to know of the expansive power of water vapor when thus at work for the welfare of man, yet so little do we know of this same expansion and condensation when in the free air.

We of the West glory, not without reason, in the achievements of our engineers. For irrigation work and in the utilization of water power, great dams and mighty reservoirs have been built. We impound and imprison the impetuous floods upon the mountain side until such time as comes the call to spread the water

o'er a thirsty land. Think what the clouds do! Reservoirs of vast capacity, though plastic and seemingly of flimsiest construction, they form and dissolve before one's eyes. But ever the load of life-giving water is lifted from the level of the sea to the peaks of the highest mountains and if need be, beyond. The cascades that charm us, the rushing streams of the mountains, the mantle of white covering the "Ultimae Sierra", all are children of the clouds and owe their being and their place to these wandering reservoirs.

Though the clouds pass hourly before us, we know comparatively little about cloud structure. An elementary knowledge of cloud formation will not be without value, and the ability to even partially decipher the meaning of a given cloud mass will not only directly benefit us, but



NURSLINGS OF THE SKY. CIRRO-CUMULI.

will add much to our appreciation of the clouds' beauty. Back of each form of grace, the intelligent observer will be able to trace controlling laws, developing and unfolding the mass of globules, breathing life as it were into the inanimate vapor. Therefore let us study these nurslings of the sky, even where they lie, even as they move in unending procession.





CLOUD EFFECTS.



IF we to-day know little about the clouds, our predecessors knew still less. The cloud was an alien and cloud effects were generally misinterpreted. Yet the clouds have played a part in history. Many a mysterious vision, many a special revelation, from Belshazar's feast to Luther's encounter with a cumulo-nimbus or thunder cloud, has been nothing but an extraordinary cloud effect. Many a spiritual awakening too has come from cloud phenomena, from deep impressions made by some unusual slant of light or some awe-inspiring cloud shadow. It is not strange

that men, especially in earlier days, should have failed to perceive and clearly understand such effects. For even until quite recent times, those who were best informed concerning natural phenomena knew little about the clouds and so could not disprove popular belief that all strange appearances were directly connected with some problem of the time. Looking for a sign, it was most natural that imaginative minds should trace in unusual cloud phenomena, the message of guidance so anxiously desired.

Is it however not strange that while men marvel at the unusual, and stand awe-struck before any marked manifestation of energy, as when the lightning leaps from cloud to cloud, they seldom lift their eyes from the commonplace things of life to the never-ending procession of the clouds? There they might

read messages of inspiration and delight traced with exquisite grace in characters of purest white or tinted with the gold and red that only cloudland knows.

Is it not also strange that the artist's eye does not always follow nor his brush perpetuate the grace of form, and beauty of color of the clouds? Speaking generally, few painters concern themselves regarding the accuracy of their cloud effects. "Nothing is more extraordinary in Art", says Professor Clayden, in his well known book on Cloud Studies, "than the general neglect of cloud forms. Many of them are quite as worthy of careful drawing as the leaves of a tree, the flowers of a field, the ripples on a stream or the texture of a carpet or marble pavement. Yet it is the common rule to find pictures which are otherwise marvellous examples



THE SILVER LINING.

of skill and care, disfigured by impossible skies, with vague, shapeless clouds which are as untrue to Nature as it would be possible to make them."

We need not expect the artist to be a cloud expert but he should at least know enough to avoid the introduction of clouds due to ascending currents, forming while the day grows warmer, in sunset or evening scenes; and conversely, the clouds common to the cold hours or formed when the earth is losing heat, should not appear in a painting representing a high sun. Some attention should be paid to the character of the cloud and its appropriate level. Few painters get their clouds in the proper level. This is largely because clouds are ever changing and vary in appearance. Sometimes low lying clouds will resemble clouds of high level; but a keen observer

can detect differences, though often slight.

When all is said and done, no painter may hope to do full justice to the clouds of sunrise and sunset nor the dazzling radiance of mid-day. And the canvas is powerless to hold and the brush tell of the inner life of the cloud, its beginning, its culmination and its disappearance. Only to him who watches, whether it be from attic window or from mountain height, is it given to know the clouds, as they pass in quiet modesty or trailing glory.

Perhaps if mankind were charged so much a head for sunsets, as Stevenson once humorously suggested, we would value them more highly. Perhaps too if we had to pay roundly for views of exquisite cloudscapes or travel far, as we do to see landscapes of rare beauty, then we should

so construct our habitations and so order the course of daily cares, as to lose nothing of the scenery of the sky.

And the gain to all men would be beyond measure.





CLOUD NAMES.



HE clouds were without names until the beginning of the nineteenth century, when at a meeting of the Askesian Society, session of 1802-3, a young chemist of Tottenham read an essay in which he proposed a cloud classification, using the terms beginning with the lowest: *nimbus*, or rain; *stratus*, or layer; *cumulus*, or rounded pile; and *cirrus*, or feather. By combining the types, all ordinary cloud forms could be included. There had been but one other attempt at cloud classification. Howard's system was so superior to this and his scheme so flexible and easy

of comprehension, that it met with general favor and ready acceptance.

Luke Howard's essay was reprinted in 1832, translated into various languages and adopted almost without change by the meteorological services of the world. While his name is known everywhere, little has been handed down concerning the man himself. I find that he is quaintly described on the title page of his three volumned *Climate of London*, as a "Citizen of London, Honorary Citizen of Madgeburg and Honorary Associate of the Art Societies of Hamburg and Leipsic." No less a person than Goethe was among those who were charmed by Luke Howard's work. A friendship sprang up, a long correspondence was carried on and the poet sings of Howard as one worthy of all honor.

But the Howardian nomenclature

is unscientific in that it classifies according to appearances, and with the clouds these are misleading. What is needed is a system showing the origin of the cloud. Modern meteorology cares little for cloud beauty, compared with significance in the matter of air motion, nucleation and thermal energy involved. Meteorology wants to use the cloud as an exponent of the rate of condensation, a means of measuring absorption and transportation of energy. Howard's system gives nothing of these and indeed it is doubtful if it ever occurred to Howard that clouds would one day be studied with spectroscope, bolometer and electrometer. Within the past five years marked advances have been made in studying the clouds of the sun. At Mount Wilson, Dr. Hale and his colleagues have by means of the spectro-heliograph thrown much

light upon the character of the hydrogen, calcium and other clouds. Indeed we almost know more of the metallic vapor clouds of the sun than we do of the water vapor clouds of earth.

Preceding Howard, the great naturalist Lamarck proposed a system for cloud classification, but like Howard's it was based largely upon appearance. Of the many investigators following Howard, and the list is a long one embracing various nationalities* few have proposed entirely new systems. Nearly all have simply modified the Howardian types. Many elaborate names have been proposed but in the main these are simply descriptive terms Latinized. Thus no less than sixteen

*Poey, Forster, Clos, Kaemtz, Fritsch, Jevons, Clouston, Muhry, Ley, Weilbach, Vettin, Klein, Köppen, Tissandier, Barker, Möller, Toynbee, Jesse, Abercromby, Hildebrandsson, Maze, Singer, Neumayer, Kassner, Clayden, Clayton, Gaster, Vincent.

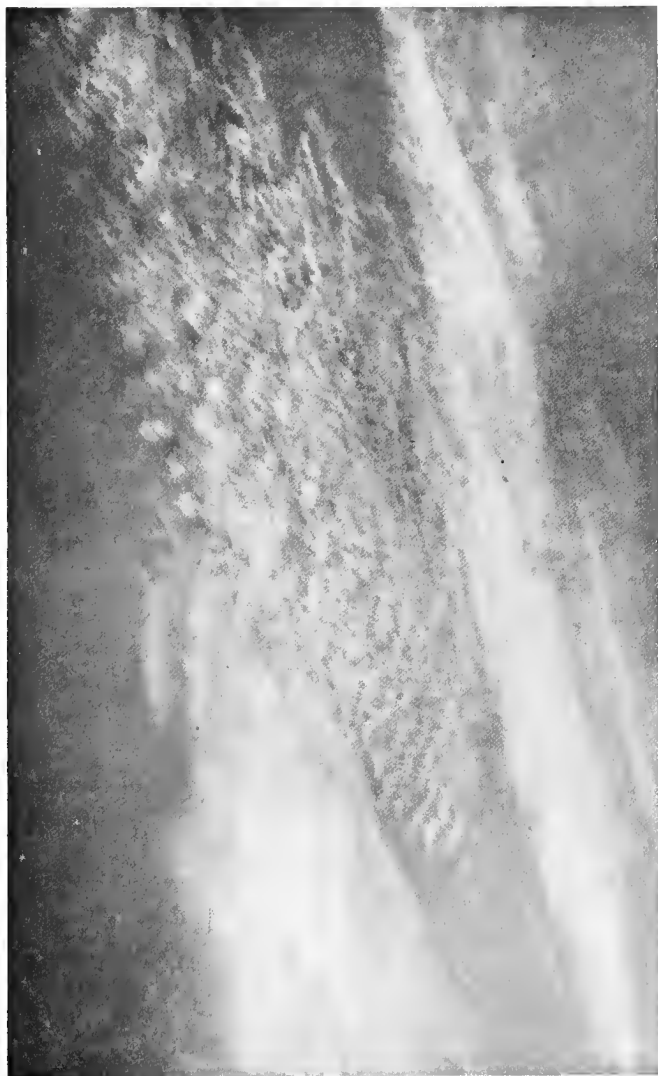
different types of *cirrus* have been suggested by various writers and an almost equally large number of sub titles for both the *cumulus* and *stratus* types.

In 1894 Clement Ley in his book *Cloudland* proposed four main classes:

1. Radiation clouds.
2. Interfret clouds.
3. Inversion clouds.
4. Inclination clouds.

Under the first are all the fog types; under the second, clouds caused by the interaction of horizontal currents; under the third, the *cumulus* clouds or clouds caused by condensation due to vertical currents; and under the fourth, the *cirrus* types.

In 1889 Clayton (an American meteorologist at Blue Hill Observatory, whose discussion of Cloud Observations in the *Annals of Harvard*



INTERFRET CLOUDS.

Observatory, Vol. XXX, Part IV, 1896, is the best that we know of), prepared a classification based upon the *origin* of the cloud.

1. A class due to local, nearly vertical ascending currents, producing the clouds called *cumulus*.

2. A class due to slow obliquely ascending air. To this belong all the sheet clouds of stratification.

3. A class due to the chilling of the lower air by radiation from the earth's surface. To this class belongs the fogs.

4. A class due to evaporation of the thinner parts of clouds already formed, probably caused by descent. To this class belong many of the clouds which appear in flocks of balls or rolls; and certain forms of *cirrus*.

5. A class of clouds due to differences in direction and velocity of the air currents at different levels. To this class belong the *cirrus*.

About 1890 an International classification was agreed upon and has been for years in general use among

meteorologists. It is a modification of Howard's system and is hardly worthy of scientific approval.

Cirrus or feather cloud. This is the highest cloud and moves with greatest velocity. It is higher in summer than in winter. Average height 10 kilometers (6 miles).

Cirro-stratus. A low *cirrus* and less stable. Solar and lunar halos are due to the diffraction of light through these clouds.

Cirro-cumulus. Small fleecy clouds without shadows or casting faint ones. They are arranged in broken layers and move rapidly. Average elevation 6 to 10 kilometers (4 to 6 miles).

Cumulus. These are dense clouds formed chiefly by uprising currents. When the cloud is opposite the sun the surfaces seen by the observer are more brilliant than the edges. When between the sun and the observer the cloud throws a strong shadow. Bases are often flat and mark a wide-spread level of condensation. The average rate of motion is 9 meters per second (20 miles per hour)

in summer; and 13 meters per second (30 miles per hour) in winter.

Alto-cumulus. Dense, fleecy clouds, grouped in flocks or rows. These are probably formed when ascending currents are less strong than in the case of *cumulus*; or they may be formed by mixture. Their average height is from 2 to 3 kilometers (1 to 2 miles), and their mean velocity about 18 meters (40 miles per hour) per second.

Cumulo-nimbus. These are the thunderheads and shower clouds. Heavy masses rising like mountains, generally with a veil of *cirrus* cloud at the top, the so-called false *cirrus*. These are the largest clouds and have been studied more completely than any other type. Some *cumulo-nimbi* measured by Bigelow, Kimball and others at Washington, show the several stages of formation, namely, the vapor, liquid and solid stadia. In one case the range of temperature was from 26° C (80° F) to -59° C (-76° F); or if expressed in the absolute scale, from 299° A to 214° A. These clouds carry a strong electrical charge and McAdie has shown that there are marked variations

in the electrical potential of the air, caused by the approach of one of these cloud masses.

Stratus. Lifted fog, or sheet cloud, of low elevation and without special structure. Formed by the mixing of air strata at different temperatures and due to horizontal movement of the air rather than rapid upward movement. Average elevation less than 800 meters (half a mile), Average velocity 7 meters per second (15 miles per hour).

Strato-cumulus. Large balls or rolls of dark cloud, covering the sky, especially in winter. Distinguished from *nimbus* by the rolled form and absence of rain. Forms at a moderate elevation, about 2743 meters (9,000 feet) in summer, and somewhat lower in winter and moves at a rate of about 11 meters per second (25 miles per hour).

Alto stratus. A thick gray or bluish veil showing brighter in the vicinity of the sun and moon and without causing halos may produce coronae. The average height is about 5.5 kilometers ($3\frac{1}{2}$ miles) in summer; and 5 kilometers (3 miles) in winter. The average velocity



CIRRUS-NEBULA.

is 18 to 22 meters per second (40 to 50 miles per hour).

Nimbus. Rain cloud. Dark, formless clouds with ragged edges from which generally rain or snow falls. When torn into small patches it is called *scud* or *fracto-nimbus*.

From what precedes it is evident that it is not easy to positively identify any given cloud. Moreover clouds of the low levels may under certain conditions closely resemble clouds of higher levels. Again clouds change form so rapidly that one can never be sure of the type.

One of the best ways to keep track of the various types and their proper levels is the following scheme:

A. Upper clouds: (a) *cirrus*; (b) *cirro-stratus*; 9,000 meters or 29,500 feet.

B. Intermediate: (a) *cirro-cumulus* and (b) *alto-cumulus*; 3,000-7,000 meters or 11,500-23,000 feet.

C. Lower: (a) *stratus-cumulus*; (b) *nimbus*; 2,000 meters or 6,600 feet.

D. Clouds of diurnal ascending currents: (a) *cumulus*; top 1,800 meters, 5,900 feet; base 1,400 meters, 4,600 feet; (b) *cumulo-nimbus*; top 3,000-8,000 meters, 9,800-26,000 feet; base 1,400 meters, 4,600 feet.

E. High fogs: (a) *stratus*; below 1,000 meters, 3,280 feet.

The Munich Conference appointed a Cloud Commission under the presidency of Professor Hildebrandsson to prepare an International Cloud Atlas. This was published in Paris, 1896, by Hildebrandsson, Riggensbach and Teisserence de Bort. Some sixteen types of clouds are given with the abbreviations used by meteorologists. They are:

Cirrus, Ci.

Cirro-stratus, Ci. S.

Cirro-cumulus, Ci. Cu.

Alto-cumulus, A. Cu.

Alto-stratus, A. S.

Strato-cumulus, S. Cu.

Nimbus, N.

Cumulus, C.
Cumulo-nimbus, Cu. N.
Stratus, S.
Fracto-cumulus, Fr. Cu.
Fracto-nimbus, Fr. N.
Fracto-stratus, Fr. S.
Stratus-cumuliformis, S. Cf.
Nimbus-cumuliformis, N. Cf.
Mammato-cumulus, M. Cu.

Some of the above types, especially the high level *cumuli* and the clouds of the *cumulo-nimbus* variety or thunder-heads, are rare in San Francisco. *Cumuli*, when they do appear, are seen mostly on the eastern horizon and are in general connected with thunderstorm conditions in the Great Valley and in the Sierra.

Far and away the most frequent cloud formation is that of the lowermost level, from sea level to 500 meters (1640 feet). The water vapor is condensed at temperatures neither high nor low, and is carried in from the sea with the prevailing west wind.



CLOUD MEASUREMENTS.



It is not an easy matter to measure the height and velocity of a cloud. Accurate measurements indeed are made only at a few of the leading meteorological observatories.

Of several methods in use, the simplest and most direct is to send up hygographs on kites or balloons and follow the position of the instruments with a theodolite. When the kites enter or come out of a cloud the height can be determined with considerable accuracy and at the same time the variations in humidity, pressure and temperature serve to further identify and establish the record. A



CIRRO-STRATUS.

second way is to follow the reflection of a cloud in a nephoscope, which is a black mirror provided with graduated circles and proper index arms. A third way is by means of simultaneous observations with alt-azimuth instruments. Two observers at a distance connected by telephone and knowing accurately the intervening base line can agree upon a definite cloud point and by means of the vertical and horizontal angles, work out the cloud height and velocity. Better yet are cameras mounted on surveyors' transits, making an instrument known as a photogrammeter. Where observations can be made from mountain observatories, the upper levels of the fog and lower clouds and the lower levels of the intermediate clouds can be readily determined by direct comparison with known heights. Thus at Mt. Tamalpais it is an easy matter to

obtain the heights of the upper level of the fog.

Finally the heights of cloud bases can be roughly determined from a knowledge of temperature decrease with elevation and the laws of condensation governing water vapor in free air. To do this one must know the temperature at different levels and the probable dew-point. Dry air cools 1°C. each hundred meters of ascent. That is, dry air when ascending and expanding normally and without receiving heat from any outside source, will cool 0.55°F. for each hundred feet. But such a condition rarely exists. Air and water vapor rising and expanding do not cool quite so rapidly. The formula used is:

$$\frac{db - dp}{0.78} = \text{altitude of base of cloud.}$$

In this formula *db* is the temperature shown by the dry bulb thermometer

properly exposed, and dp is the dew-point.

Few scientific investigations are more interesting than exact measurements of the clouds. One can follow in this way the local ascending currents, the formation of clouds, the inclination of cloud sheets and in brief the whole circulation from the moment evaporation begins until the raindrop or snowflake forms and falls; the water again seeking the broad level of the sea, to begin its wandering afresh.

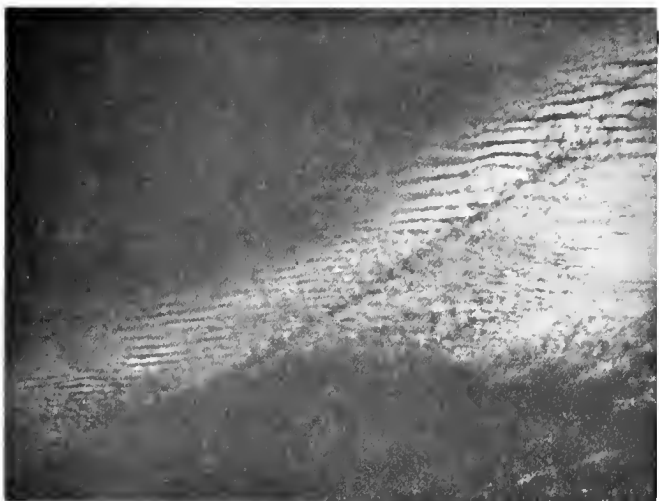




TRACKING THE CLOUDS.



HERE is a river in the ocean. So began Maury's famous book, the many editioned Physical Geography. He was describing the Gulf Stream with its fountain in the Gulf of Mexico and its mouth in Arctic seas; and although subsequent study and discovery have materially modified the original conception of the stream and its importance in controlling the climate of England, nevertheless the tracking of an individual current in the great spread of Atlantic waters was an achievement worthy the recognition it received from the nations. There are other rivers in



CIRRO-CUMULI (1). *Compare with plate below.*



CIRRO-CUMULI (2). *One minute change.*

the seas. In the Atlantic no less than twelve well marked currents and drifts are now charted; and in the Pacific at least ten. The best known of the Pacific currents are the Kuroshiwo or Japan current, passing partly into the Sea of Japan, but mostly washing the southeast coast of the Islands and then drifting eastward; the California current which flows from the North Pacific southeast, south and then southwest, becoming finally a westerly drift; and the North Equatorial current which under the influence of the Trade Winds flows westward with a velocity of ten or more miles per day from the Central American coast, recurving gradually, northward, as it reaches the Philippines.

But if there are many rivers in the sea, there are more rivers in the larger ocean, the atmosphere. In fact the great water currents are set

in motion and driven in large degree by the currents of air. Certain winds, such as the Trades, the Counter Trades, the Prevailing Westerlies, and Roaring Forties (referring to the winds rather than the latitudes), are well known. Meteorologists have been busy for many years sounding the ocean of air and charting the main streams and drifts. But even more than this, is the determination of temperatures, pressures, humidities, wind velocities and the flow of the air at all levels from the ground up to the level of the highest clouds. In studying the currents of the sea, men are concerned chiefly with surface movements; but in aerial work we must know not only the movements near the ground and in a horizontal direction, but all the uprising and descending currents. Charts of the atmosphere are now published; and

in such a book as the one issued this year, 1911, by Professors Rotch and Palmer, aviators and aeronauts can find for their guidance, the prevailing conditions at various levels. For example, the wind velocity increases with height and the increase is greater in winter than in summer; but during the late spring and early autumn the increase between 500 meters (1640 feet) and 1500 meters (4921 feet) is very gradual. Again, the sea breeze is found to be a shallow stream while winds from the same direction, but of cyclonic origin, are of considerable depth. Winter winds are stronger than summer winds at nearly all levels, and westerly winds stronger than easterly winds.

The possibility of utilizing the great rivers of the atmosphere in aerial navigation naturally suggests itself. Indeed the problem of using

the Trade Winds for passages from Europe to America has been discussed; and while practicable, it has been pointed out by Professor Rotch that to make the return advantageously one would have to rise above the Counter Trades, owing to their irregularity, and utilize the eastward drift in the *cirrus* level. This can be done and in the future may be accomplished, but at present both for comfort and safety another route which however is far north, will have to be taken.

Over the Pacific, air lanes of travel have not yet been charted with any great detail. Leaving the Asiatic coast the lower winds during many months would carry the traveller to Alaska; but the strong northwest winds of summer could be used to come south. The return trip could best be made by leaving the American coast south of California and



CUMULI.

utilizing the northeast Trades. If cloud masses were as permanent and substantial as air ships we should have had long before this a better knowledge of the currents of the atmosphere. But because they form and dissolve so rapidly and incessantly and can not long be identified, meteorologists have found it a difficult matter to determine true air motion by study of the clouds.





THE FOGS.



FOG is *San Francisco's greatest asset*. This sounds quixotic, but the statement is nevertheless true. For while fog is an active and permanent menace to navigation, a source of uncertainty and delay and worry to travellers, and carries a chill that goes to the very marrow of thinly-clad summer tourists, nevertheless it keeps the city cool in summer and thus makes for health; also it keeps the city warm in winter, preventing frosts and moderating the fall in temperature. The lowest recorded temperature at San Francisco is -2°C . (29°F .), and the highest 38°C . (101°F .) The

mean temperature is 13°C. (56°F.) San Franciscans love their fog. When away from the city they pine for it, and especially during summer. Not without reason do they appreciate the cooling effect of the fog. It enables one to sleep through summer nights and rise refreshed and ready for the day's requirements.

Owing to the peculiar topography of the San Francisco Bay section, the prevailing westerly winds (sometimes erroneously called Trades) have their velocity increased near the Golden Gate. There are certain well-marked stream lines in the general current from west to east, and in these streams large quantities of the condensed water vapor lying beyond the heads and along the coast, are carried in through the Gate, at heights varying from sea level to 500 meters (1640 feet). There are times when the formation of the fog is purely local

50 *THE CLOUDS AND FOGS*

and the area covered small; but there are also times when a bank of fog will extend along the coast 2000 kilometers (1244 miles).

In general the fog hugs the coast and is most dense a short distance from the shore line; but occasionally it will cover the sea for hundreds of miles and be reported by steamers several days out from port.





CHANGING ALTO-CUMULI (1). *Compare with plate below.*



CHANGING ALTO-CUMULI (2). *One minute later.*



TYPES OF FOG.



IN the vicinity of San Francisco there are several well-marked types of fog. First and most prominent is the summer afternoon sea fog which forms not far west of the Gate, and at times within the Gate, on the Sausalito hills and south slopes of Tamalpais, and moves inland at an average rate of 7 meters per second, 16 miles per hour. The second type is the tule fog, named from the tules or bulrushes in the Sacramento-Joaquin river beds. This is a low-lying, dense land or river fog, which forms during winter mornings and drains slowly seaward, half a meter per

second or a mile an hour. It is essentially a valley fog and is most marked in the lowlands; but sometimes on clear winter nights when the cooling due to radiation is marked, fog forms early over the city and bay, dissipating before noon. As a rule the city hills and even the roofs of the tall office buildings are above the fog. Although there are certain ascensional movements, the high parts of the city are generally out of the fog several hours before the low portions.

The third type is a nondescript fog, formed by a mixture of city smoke and dust with the condensed vapor. This lies about 200 meters, or 650 feet, above the city streets. A pall of smoke and fog drifts slowly seaward during the morning hours, especially in the spring and autumn, and returns again about one p.m., driven in by the west wind. In such

cases it appears as a dark, low cloud and for a period of fifteen minutes or half an hour causes a noticeable darkness.

At Mt. Tamalpais one may look down upon the fog and note the various stream lines. There are marked differences in temperature, humidity and air motion within comparatively short distances both in a horizontal and vertical direction. The whole Bay section is remarkable and may indeed be considered as a magnificent natural laboratory in which experiments bearing upon the cloudy condensation of water vapor are wrought daily. Ocean, bay, mountain and foothill lie in close juxtaposition. A valley level as a table is connected with the ocean by a narrow water passage, while on either side are hills reaching in some cases above the 1000 meter (3280 feet) level.

In summer the afternoon sea fog varies in depth from 30 meters (100 feet) to 500 meters (1640 feet), the depth decreasing as the distance inland increases. On summer afternoons the velocity of the wind at San Francisco rises with almost clock-like regularity to about 10 meters per second or 22 miles per hour, and a solid wall of fog comes through the Golden Gate, causing a fall in temperature to 13°C. (55°F.) which is approximately the temperature of the surface water of the sea in this latitude. The upper level of the fog can be plainly seen from the high hills in the vicinity. Moreover above the fog level the air is cloudless and the temperature is often as high as 33°C. (90°F.)

The Pacific fogs are different from the fogs of the North Atlantic, for the latter occur irregularly, although in certain localities persistently, and



HOW THE FOG COMES IN AT SAN FRANCISCO.

are due probably to thin strata of warm moist air passing over cold water surfaces. On the other hand our Pacific fogs are more probably due to the mixture of two air streams, one warm and the other not so warm, but heavily laden with water vapor. The moisture of the lower current is cooled by a slight uplifting and expansion; but above a certain limit no fog forms owing to the warmer air stream moving slowly seaward or in an opposite direction from the lower fog-laden current. The supply of water vapor comes from the sea and there is probably some direct connection between the steady and strong northwest winds and the direction and force of the ocean currents in this section. Both the air and water isotherms bend sharply southward in the latitude of 40° north and longitude 130° west. The water is somewhat warmer than the

air. It must be remembered, however, that the air temperature is that of the lowermost level and does not correctly indicate the true temperature of the general air mass. One would naturally anticipate that the water would be colder than the air since both move from the north and water has a higher specific heat.

Cooling is necessary to produce condensation and this may be accomplished by an uplifting of the air mass with resulting expansion and work done against pressure at a given level, or by the radiation and loss of heat when the upper air is dry, dust-free and vapor-free, or finally by mixture with cold air.

As yet very little is known about the nuclei which serve as centers of condensation, and until this phase of the problem is investigated, we cannot speak definitely concerning the origin of fog.



SUNSHINE AND FOG.



COMPARING San Francisco with other cities in the United States, it must be admitted that the amount of sunshine received is not as large as it ought to be. Nevertheless the city receives a larger amount than the general prevalence of sea fogs would lead one to believe. An interesting comparison is that of San Francisco and Baltimore, the latter a coast city slightly farther north, however, than San Francisco. We find that the mean percentage of possible sunshine at Baltimore for the month of January is 50 per cent. and at San Francisco 46 per cent.; for February at

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Baltimore 59 per cent. and at San Francisco 52 per cent.; for March at Baltimore 57 per cent. and San Francisco 56 per cent. It therefore appears that during the first three months of the year there is more sunshine in Baltimore than in San Francisco. During April, May and June, however, San Francisco has more sunshine, as shown by the following table:

<i>April</i> —	Baltimore 60 per cent.
	San Francisco 67 per cent.
<i>May</i> —	Baltimore 54 per cent.
	San Francisco 64 per cent.
<i>June</i> —	Baltimore 62 per cent.
	San Francisco 84 per cent.

The effect of the summer fogs in reducing the amount of sunshine at San Francisco is strikingly shown by the records for the months of July and August. Attention is called to the table (page 67), showing the



FOG CASCADES.

effect of the fog between 7 a.m. and 9:30 a.m.; and 6 p.m. and 8 p.m. during July, August and September.

For July the average percentage of sunshine at Baltimore is 63 per cent. and at San Francisco 65 per cent.; for August at Baltimore 61 per cent. and at San Francisco 58 per cent.; for September at Baltimore 67 per cent., San Francisco 65 per cent.; for October at Baltimore 60 per cent. San Francisco 67 per cent.; for November at Baltimore 50 per cent.; San Francisco 57 per cent.; for December at Baltimore 51 per cent. and at San Francisco 55 per cent.

It is thus seen that during the months of October November and December there is a higher percentage of the possible sunshine at San Francisco. For the year the average percentage of possible sunshine at Baltimore is 58 per cent. and at San Francisco 60 per cent. The figures

for Baltimore are taken from Dr. Fassig's report on the Climatology of Maryland.

If we compare San Francisco with other large American cities, we find there were in a given year:

- 2729 hours of sunshine at New York.
- 2423 hours of sunshine at Chicago.
- 2548 hours of sunshine at Philadelphia.
- 2763 hours of sunshine at Boston.
- 2263 hours of sunshine at St. Louis.
- 2266 hours of sunshine at Pittsburg.
- 2869 hours of sunshine at San Francisco.

These data are from the last Annual Report of the Chief of the Weather Bureau.



Percentage of Sunshine at Mt. Tamalpais
13 Years' Records to 1910-11.

	5	6	7	8	9	10	11	M.
	A. M.	A. M.	A. M.	A. M.	A. M.	A. M.	A. M.	
January.....			50	42	46	50	53	54
February.....		49	49	48	52	55	58	57
March.....		56	63	52	56	59	59	58
April.....	69	67	71	70	74	76	77	76
May.....	78	79	82	76	72	81	82	83
June.....	91	89	90	86	87	90	91	91
July.....		84	87	92	94	95	96	96
August.....		81	80	88	91	93	93	94
September.....			68	82	85	87	97	88
October.....			54	71	77	78	80	80
November.....				50	59	63	62	64
December.....				56	61	67	68	68

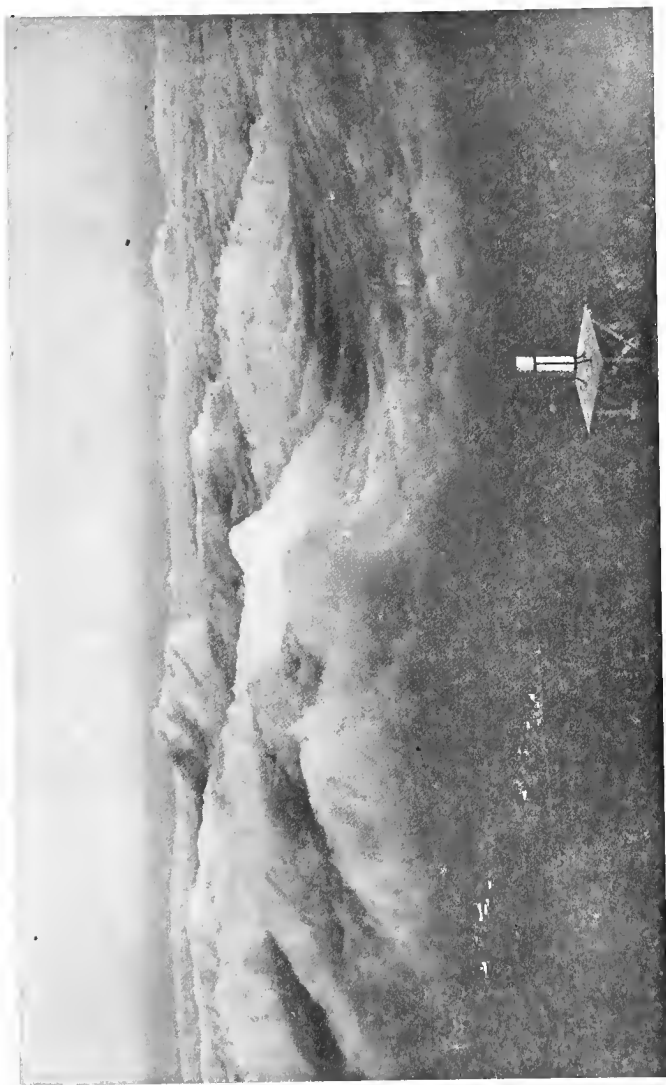
	1	2	3	4	5	6	7	8
	P. M.	P. M.	P. M.	P. M.	P. M.	P. M.	P. M.	P. M.
January.....	51	52	51	46	40	39	.....	.....
February.....	60	61	58	55	49	43	.....	.....
March.....	62	64	63	59	55	45	43	.....
April.....	80	80	80	79	77	70	63	.....
May.....	85	86	86	86	84	78	70	67
June.....	93	95	95	94	94	90	87	82
July.....	97	98	98	98	97	96	93	93
August.....	95	96	97	97	96	94	92	91
September.....	89	90	90	90	87	85	85
October.....	81	81	81	78	82	71
November.....	65	65	64	59	52
December.....	70	62	64	53

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Percentage of Sunshine at San Francisco
18 Years' Records to 1910-11.

	5	6	7	8	9	10	11	M.
	A. M.	A. M.	A. M.	A. M.	A. M.	A. M.	A. M.	
January.....				22	33	48	57	61
February.....			28	24	40	53	60	67
March.....		16	29	36	49	60	69	71
April.....		33	41	52	65	74	79	83
May.....	33	38	48	54	65	74	81	85
June.....	42	42	53	63	73	84	90	93
July.....	29	24	32	41	55	71	86	93
August.....		17	21	28	39	58	77	89
September.....		28	34	44	57	69	79	86
October.....			34	43	55	67	78	83
November.....			29	30	43	56	67	73
December.....				30	42	56	65	69

	1	2	3	4	5	6	7	8
	P. M.	P. M.	P. M.	P. M.	P. M.	P. M.	P. M.	P. M.
January.....	64	64	61	49	36	30	.....	.....
February.....	69	71	68	64	51	34	.....	.....
March.....	75	75	74	88	60	42	36	.....
April.....	85	84	83	79	70	59	48	.....
May.....	86	88	85	81	72	58	45	37
June.....	94	95	95	94	86	72	62	52
July.....	97	97	97	93	82	61	43	42
August.....	93	96	95	85	71	44	31	31
September.....	90	90	89	80	68	54	42	.....
October.....	87	88	85	79	61	48	.....	.....
November.....	76	76	72	61	42	.....	.....	.....
December.....	70	67	64	51	36	.....	.....	.....



Fog Surges.



THE FOG CURTAIN AND THE SUN.



VERY minute of sunshine has been recorded for the past thirteen years at Mt. Tamalpais. And as the same has been done at San Francisco, but for even a longer period, we are able to say with some certainty how much sunlight is shut out from the lower station by the curtain of fog, since during most of the year the curtain is drawn below the level of the summit.

In an average year the total number of hours of bright sunshine at San Francisco will be about 2900. Above the fog curtain, say at a height of two thousand feet, there would be

about 3400 hours. Therefore the curtain shuts out about 15 per cent. of the possible sunlight. And this screening takes place chiefly in the morning and evening hours when indeed the sunlight is most welcome. We could better spare the sunlight in the noonday hours. However, in midsummer, the fogs do materially temper the heat and diminish the glare. In August the city receives but 68 per cent. of the possible sunshine, while the mountain receives 80 per cent., and in some years 100 per cent. of the possible amount.

Once in a while the city receives more sunshine than the mountain does. This is apt to occur during March or some of the winter months. At such times clouds form on the mountain crest and remain there; but in the valleys and at sea level there is bright sunshine.



FOG AND EQUIVALENT RAIN.

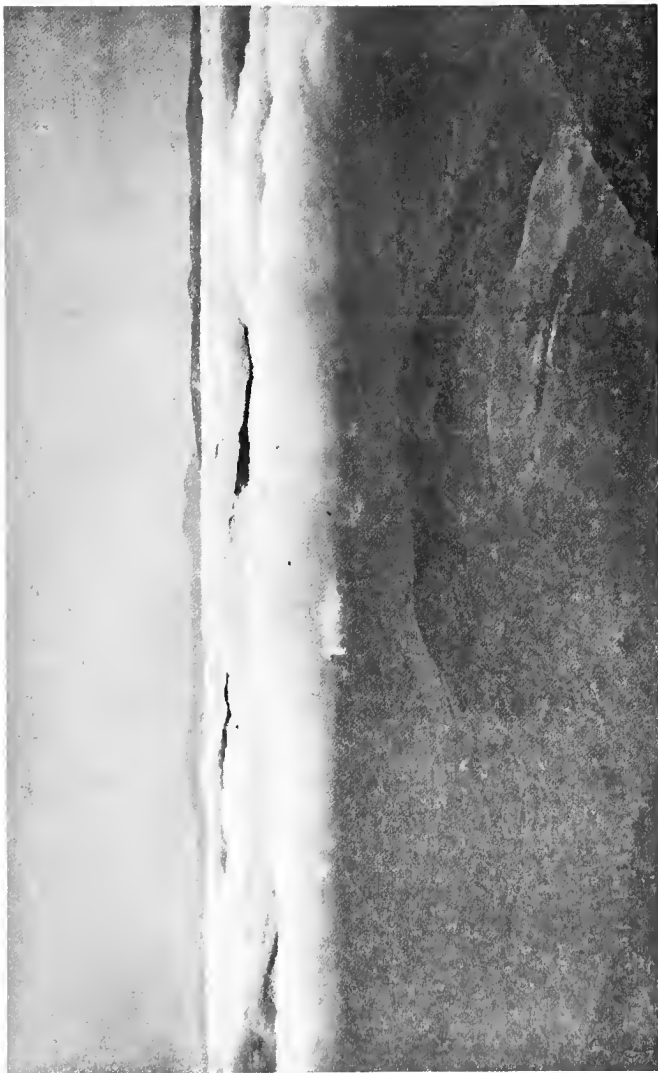


WATCHING the fog masses pour through the Gate, the question naturally arises: "Could this vapor be condensed; and if so how much rain would result?" Fog can be dissipated by electrical agencies and the experiments of Lodge and others are fascinating and point a way toward the eventual control of fog. But at the present time fog dissipation on a commercial scale has not been attempted. The experiments of a Californian, Dr. Cottrell, in smoke deposition and his successful removal of poisonous gases in smelter fumes, offer perhaps the

first approach to commercial clarifying of the atmosphere.

As to the water content of a given fog mass: on an ordinary foggy afternoon in mid-summer, probably not less than a million tons of water are carried each hour inland, over a line drawn from Point Lobos to Point Bonita. If this vapor could be condensed and all fall as rain, which however would not be a simple process, there would be on each acre about 0.14 inch of water.

As a matter of fact, on very moist nights, or when supersaturation occurs, we find about 0.02 inch of water in the rain gage, in twelve hours. It is plain then that nearly all the visible vapor or fog is carried inland, and as the temperature rises becomes invisible and acts just like a dry gas. But in its eastern march it rises, and rising expands and cools. If the cooling is rapid



MORNING FOG OVER THE VALLEYS.

the clouds form; and thus we find as it were, a second birth of the cloud form and recognize in the curling wisps of white above the Sierra the same vapor that in an earlier existence we knew as sombre fog.





PAST AND FUTURE OF THE FOG.

FRE yet our English Bible had been translated and before Shakespeare had learned his letters, the first visitors to our shores bitterly abused our climate. And they came in June, too. The crew of the *Golden Hinde*, who left Plymouth forty years before the Pilgrim Fathers and spent nearly a month near Point Reyes Light, said some exceedingly harsh things about our weather and particularly of the fog. According to the Chaplain, these first globe-encirclers did not "in the whole fourteene days together find the air so clear to be able to take the

height of sunne or starre.” The mildest terms used in describing the fog were:

“Most vile, thick and impenetrable.”

Little did they know that the same fog shut them out from the Bay of San Francisco. They had passed north of it and rather far out, but even when they left and sailed southwest within twenty miles of the Gate, they knew nothing of it. Full of wonder as the trip had been, when they got back to England they could not tell of a glorious stretch of inland water, fog wrapped it is true at the western end, but sunlit within and beyond the reaching of the fog. The union of lordly rivers, the broad fields of a great valley quivering in the summer heat, the mighty trees and snow clad peaks remained undiscovered. The fog hid from their view the gateway to a delectable land;

and Drake who formally and with some show took over the sovereignty of the land, never dreamed that in his voyage round the world he missed an empire through a veil of fog. Within five hours sail from where he careened his little ship he and his shivering men could have basked in sunshine and enjoyed the warmth of perfect June days. How they would have marvelled at the change, for many marvel now at the marked transition from cold to warmth.

If some prophetic dreamer in the crew had told these rough men that in eight generations men of flesh and blood like themselves, speaking the same mother tongue, were to sail these waters in iron ships, by harnessing the expansive power of water vapor—nay, more, that because of their steam engines they could sail at will and neither wind nor wave bar their progress, then these bluff



FOG PYRAMID FROM MT. TAMALPAIS.

mariners in leather jerkins would have laughed uproariously and howled aloud their derision.

And are not we today somewhat like the crew of the *Golden Hinde* in that we do not see beyond the veil of the immediate present and dream not of the possibilities of the future? There is more to a bank of fog than the accidental grouping of little globules of condensed water vapor. There is a reason for the massing and there are processes at work which if understood and mastered would lead to marvellous achievement. It is as difficult for us to conceive of future methods of communication and transportation as it was for the sailors of Drake's age to imagine a steam driven ship.

Looking at the fog masses as they silently spring into being and again as silently disappear, one wonders at the forces involved. Back of

condensation is nucleation and back of that ionization. Each atom holds a number of electrical particles each of which in turn carries a certain electrostatic charge. There are positive ions and negative ions, the former having lost electrons and the latter having gained. The mechanical activity of the smallest negative ion is greater than that of the smallest positive. In some way not now clearly understood potential gradients rise rapidly in a cloud mass and there are differences of potential amounting to several hundred volts within a foot or two. Who that has ever seen the lightning play during a thunderstorm has not wondered at the apparently endless supply and waste of energy? An intense flash represents the using up of 10,000 kilowatts per second. In other words seven million foot pounds of energy. This is a large quantity from an

electrical standpoint; but when expressed in terms representing heat energy it is not much more than the latent heat of evaporation or condensation of ten pounds of water. Think then of how much equivalent electrical energy there may be in the making of an ordinary fog bank! When shall we know enough to utilize this energy? One of the brightest of American electricians, Steinmetz, has likened the discharge of a cloud to a landslide, which sets off a series of landslides. He asks us to imagine

“ . . . a relief map built of wet sand, the hills representing the dense portion of the cloud or the places of high potential, and the valleys the light or low potential places. Then where the declivity is very steep a slide occurs which causes another slide and so on, until the hills are levelled and the valleys filled, or in other words the electric potential is equalized.”

Another physicist* has thrown light upon the collision of ions with atoms and shows how ionization proceeds by geometric progression. In the air close to a wire carrying a current of electricity of very high potential, such as some of our high transmission lines in California, there is collision of the atoms and faint luminosity which is of course best seen at night. This is the probable cause of the corona or faint bluish light seen at night on high tension electrical conductors. As for the fog, meteorologists hope to be able to trace the real beginning of nucleation, haziness and condensation in the play of the ions and electrons. Then will the sombre masses of water vapor that move overhead and dim the brightness of the sun take on a new significance, and in the fog men will read a wonder tale of forces now all unknown and unmeasured.

*Professor Harris J. Ryan, of Stanford University



ABOVE THE FOG.



SIXTY-TWO YEARS OF RAINFALL.

IN no portion of the habitable globe are seasonal rainfalls more closely watched and studied than in California. There are many sections of the United States where departures from normal conditions are followed with interest; but there is no district where an excess or deficiency in rainfall means more or is more directly and vitally connected with the welfare of the community than in our own State. The history of each year's rainfall is written in the crop yield and in our material prosperity. If rain falls in sufficient amount within seasonal

limits and is well distributed as to time and amount, a good year based upon abundant crop yield may be anticipated. On the other hand, scanty rainfall, or even an average rainfall badly distributed means poor harvests and their consequences. As agriculture underlies commercial prosperity, it is plain that the activities and industries of the State are bound up with and directly dependent upon the seasonal rainfall and the resulting supply of water.

Not without reason then do our people at the beginning of each rainy season take an interest in the frequency and intensity of the rains and try to forecast the character of the impending season.

The accompanying diagrams of seasonal rainfall (page 101) first came into prominence during a period of drought, the dry seasons of 1897-98 and 1898-99, when there was a

widespread uneasiness and general misapprehension that the climate was permanently changing. The charts show conclusively that such periods are only incidental and no true indication of a permanent change.

It is plain that there is no regular sequence of wet and dry seasons, and this is as it should be, because while law is supreme in meteorology and our storms develop, move and disappear in accordance with physical laws, understood in part, there are too many independent variables entering into the problem of rain formation and the condensation of the water vapor of the air to allow us to hope for a regular and easy solution of the problem. An abnormally wet month is not necessarily followed by another of the same character. No one can predict from the existence of one dry month in winter that the balance of the season will be dry.

All that we can say at present is that wet seasons and dry seasons come and go in a very irregular way. Nor is there any determinable period between abnormal conditions. The chart herewith covers the rainfall for sixty-two years at San Francisco. If we divide the period into decades, we have:

SAN FRANCISCO.	
SEASONS.	INCHES.
10 seasons, 1849-1859:	5778 mm. or 227.47
10 seasons, 1859-1869:	6549 mm. or 257.85
10 seasons, 1869-1879:	5766 mm. or 227.00
10 seasons, 1879-1889:	5950 mm. or 234.23
10 seasons, 1889-1899:	5558 mm. or 218.81
10 seasons, 1899-1909:	5341 mm. or 210.28

The mean seasonal rainfall is 583mm. or 22.90 inches.

It is interesting to note that during the month of January, 1862, more rain fell in one month than the normal annual rainfall.



HELMHOLTZIAN FOG BILLOW.

TABLES
SHOWING MONTHLY, SEASONAL AND
ANNUAL RAINFALL
1849-1911

THE RAINFALL.

San Francisco Rainfall—Monthly, 1849-1880

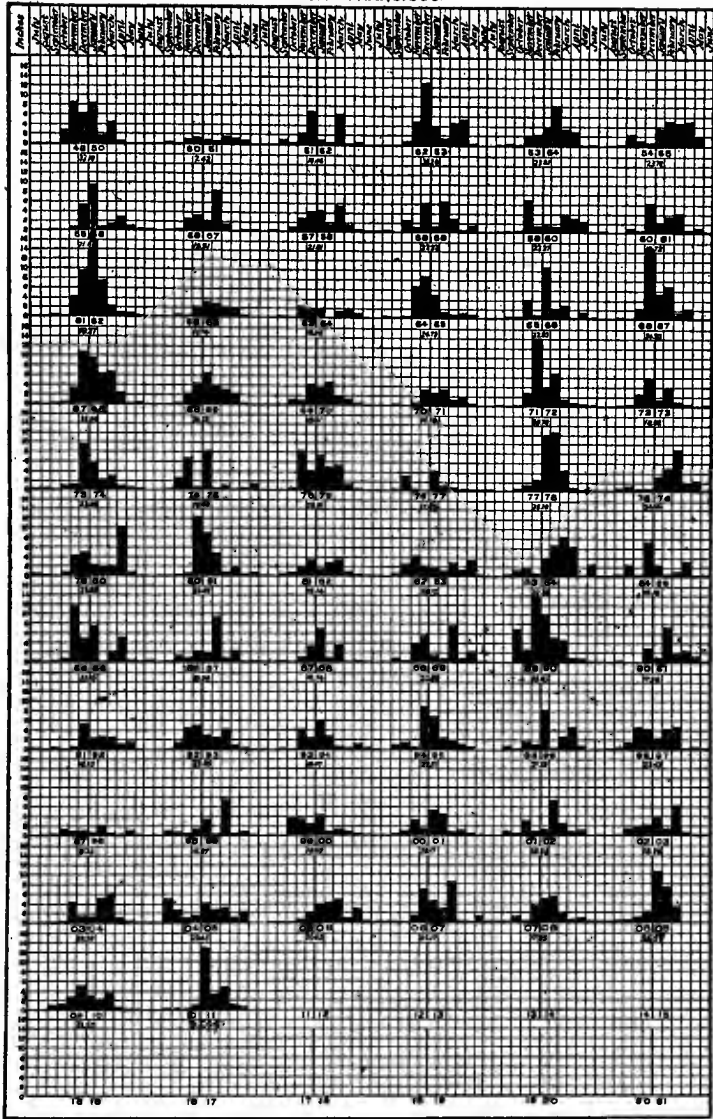
Year	Jan.	Feb.	March	April	May	June
1850	8.34	1.77	4.53	0.46	0	0
1851	0.72	0.54	1.94	1.23	0.67	0.02
1852	0.58	0.14	6.68	0.26	0.32	0
1853	3.92	1.42	4.86	5.37	0.38	0
1854	3.88	8.04	3.51	3.12	0.02	0.08
1855	3.67	4.77	4.64	5.00	1.88	0
1856	9.40	0.50	1.60	2.94	0.76	0.03
1857	2.45	8.59	1.62	0	0.05	0.12
1858	4.36	1.83	5.55	1.55	0.34	0.05
1859	1.28	6.32	3.02	0.27	1.55	0
1860	1.64	1.60	3.99	3.14	2.86	0.09
1861	2.47	3.72	4.08	0.51	1.00	0.08
1862	24.36	7.53	2.20	0.73	0.74	0.05
1863	3.63	3.19	2.06	1.61	0.23	0
1864	1.83	0	1.52	1.57	0.78	0
1865	5.14	1.34	0.74	0.94	0.63	0
1866	10.88	2.12	3.04	0.12	1.46	0.04
1867	5.16	7.20	1.58	2.36	0	0
1868	9.50	6.13	6.30	2.31	0.03	0.23
1869	6.35	3.90	3.14	2.19	0.08	0.02
1870	3.89	4.78	2.00	1.53	0.20	0
1871	3.07	3.76	1.05	1.89	0.23	0.01
1872	4.03	6.90	1.59	0.81	0.18	0.04
1873	1.58	3.94	0.78	0.43	0	0.02
1874	5.66	2.21	3.36	0.90	0.66	0.14
1875	8.01	0.32	1.30	0.10	0.22	1.02
1876	7.55	4.92	5.49	1.29	0.24	0.04
1877	4.32	1.18	1.08	0.26	0.18	0.01
1878	11.97	12.52	4.56	1.06	0.16	0.01
1879	3.52	4.90	8.75	1.89	2.35	0.05
1880	2.23	1.87	2.08	10.06	1.12	0

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San Francisco Rainfall—Monthly, 1849-1879

Year	July	Aug.	Sept.	Oct.	Nov.	Dec.
1849	0	0	0	3.14	8.66	6.20
1850	0	0	0.33	0	0.92	1.05
1851	0	0.02	1.03	0.21	2.12	7.10
1852	0	0	0	0.80	5.31	13.20
1853	0	0.04	0.46	0.12	2.28	2.32
1854	0	0.01	0.15	2.43	0.34	0.87
1855	0	0	0	0	0.67	5.76
1856	0.02	0	0.07	0.45	2.79	3.75
1857	0	0.05	0	0.93	3.01	4.14
1858	0.05	0.16	0	2.74	0.69	6.14
1859	0	0.02	0.03	0.05	7.28	1.57
1860	0.21	0	0	0.91	0.58	6.16
1861	0	0	0.02	0	4.10	9.54
1862	0	0	0	0.52	0.15	2.35
1863	0	0	0.03	0	2.55	1.80
1864	0	0.21	0.01	0.13	6.68	8.91
1865	0	0	0.24	0.26	4.19	0.58
1866	0	0	0.11	0	3.35	15.16
1867	0	0	0.04	0.20	3.41	10.69
1868	0	0	0	0.15	1.18	4.34
1869	0	0	0.12	1.29	1.19	4.31
1870	0	0	0.03	0	0.43	3.38
1871	0	0.02	0	0.07	2.81	14.36
1872	0.01	0	0.04	0.11	2.79	5.95
1873	0.01	0.08	0	0.83	1.16	9.72
1874	0	0	0.02	2.69	6.55	0.33
1875	0	0	0	0.24	7.27	4.15
1876	0.01	0.01	0.38	3.36	0.25	0
1877	0.02	0	0	0.65	1.57	2.66
1878	0.01	T.	0.55	1.27	0.57	0.58
1879	0.01	0.02	T.	0.78	4.03	4.46

SAN FRANCISCO



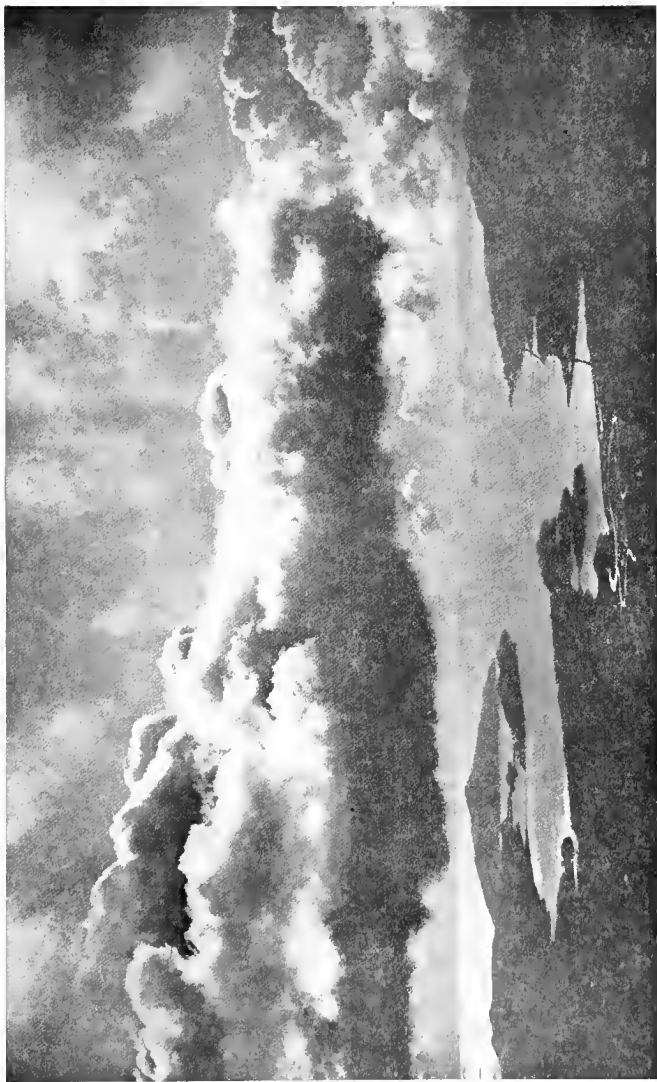
San Francisco Rainfall—Monthly, 1881-1915

Year	Jan.	Feb.	March	April	May	June
1881	8.69	4.65	0.90	2.00	0.22	0.69
1882	1.68	2.96	3.45	1.22	0.21	0.04
1883	1.92	1.04	3.01	1.51	3.52	0.01
1884	3.94	6.65	8.24	6.33	0.23	2.57
1885	2.53	0.30	1.01	3.17	0.04	0.19
1886	7.42	0.24	2.07	5.28	0.37	0.01
1887	1.90	9.24	0.84	2.30	0.06	0.07
1888	6.81	0.94	3.60	0.11	0.38	0.27
1889	1.28	0.72	7.78	0.96	2.17	0.03
1890	9.61	5.16	4.73	1.18	1.07	0.10
1891	0.98	7.26	1.96	2.44	1.25	0.11
1892	2.42	2.90	2.85	1.39	1.86	T.
1893	3.05	2.75	4.08	1.03	0.15	0.03
1894	5.99	2.69	0.60	0.50	1.31	0.56
1895	6.99	2.31	1.89	1.24	0.60	0
1896	8.14	0.28	2.85	5.16	0.72	0
1897	2.26	4.41	4.56	0.27	0.61	0.22
1898	1.12	2.13	0.24	0.19	1.44	0.19
1899	3.67	0.10	7.61	0.62	0.86	0.01
1900	4.11	0.64	1.91	1.08	0.32	0.05
1901	5.79	5.03	0.80	1.64	0.69	T.
1902	1.23	7.27	2.65	0.98	1.05	T.
1903	3.73	1.76	6.23	0.56	T.	T.
1904	1.05	5.89	6.01	1.29	0.30	T.
1905	4.04	2.70	3.15	1.33	2.05	0
1906	3.90	4.30	5.02	0.92	2.75	0.56
1907	4.41	3.02	8.42	0.11	0.04	1.28
1908	4.88	5.39	0.90	0.22	0.76	0.01
1909	10.51	7.53	3.27	T.	T.	T.
1910	3.24	2.09	3.78	0.31	0.03	.02
1911	13.79	3.02	4.57	0.89	0.28	.03
1912
1913
1914
1915

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San Francisco Rainfall—Monthly, 1880-1915

Year	July	Aug.	Sept.	Oct.	Nov.	Dec.
1880	0	0	0	0.05	0.33	12.33
1881	0	0	0.25	0.54	1.94	3.85
1882	0	0	0.26	2.66	4.18	2.01
1883	0	0	0.42	1.48	1.60	0.92
1884	T.	0.04	0.33	2.55	0.26	7.68
1885	0.06	T.	0.11	0.72	11.78	4.99
1886	0.23	T.	0.01	1.48	0.84	2.07
1887	T.	0.01	0.29	T.	0.99	3.34
1888	0.01	0.01	0.98	0.13	3.99	5.80
1889	0.01	T.	T.	7.28	2.90	13.81
1890	0.02	0	0.31	0	0	3.25
1891	0.10	0.02	0.77	0.04	0.56	5.62
1892	0	0	0.02	1.65	3.91	5.08
1893	0.02	0	0.21	0.16	4.18	2.25
1894	T.	0	1.05	1.73	0.88	9.01
1895	0.01	0	0.77	0.11	1.78	1.43
1896	0.04	0.09	0.52	1.55	4.56	4.34
1897	T.	T.	0.10	1.70	1.05	1.22
1898	0	T.	1.06	0.86	0.46	1.62
1899	0	T.	0	3.92	3.79	2.65
1900	T.	T.	0.46	1.48	3.91	1.37
1901	T.	T.	0.78	0.64	3.48	0.90
1902	T.	T.	T.	1.70	1.98	2.32
1903	0	T.	T.	0.17	4.25	1.63
1904	0.02	0.06	5.07	2.37	1.07	1.59
1905	0	T.	T.	T.	0.92	2.05
1906	0.08	0.11	0.18	0.03	1.59	6.90
1907	T.	0.02	0.11	1.36	0.04	3.66
1908	0.02	0.01	0.13	0.61	1.34	2.15
1909	0	T.	0.80	1.23	2.43	5.59
1910	T.	0	0.05	0.65	0.48	1.73
1911	0	0	T	....	....	....
1912	....	....	....	....	....	....
1913	....	....	....	....	....	....
1914	....	....	....	....	....	....
1915	....	....	....	....	....	....



FOG CHANGING TO CLOUD, SAN FRANCISCO BAY

Seasonal and Annual Rainfall—1849-1911

Seasonal	Year	Annual	Seasonal	Year	Annual
33.10	1850	17.40	20.12	1883	15.43
7.42	1851	15.60	32.38	1884	38.82
18.46	1852	27.29	18.10	1885	24.90
35.26	1853	21.17	33.05	1886	20.02
23.87	1854	22.45	19.04	1887	19.04
23.76	1855	26.39	16.74	1888	23.03
21.66	1856	22.31	23.86	1889	36.94
19.91	1857	20.96	45.85	1890	25.43
21.81	1858	23.46	17.58	1891	21.11
22.22	1859	21.39	18.53	1892	22.08
22.27	1860	21.18	21.75	1893	17.91
19.72	1861	25.52	18.47	1894	24.32
49.27	1862	38.63	25.70	1895	17.13
13.74	1863	15.10	21.25	1896	28.25
10.08	1864	21.64	23.43	1897	16.40
24.73	1865	14.06	9.38	1898	9.31
22.93	1866	36.28	16.87	1899	23.23
34.92	1867	30.64	18.47	1900	15.33
38.84	1868	30.17	21.17	1901	19.75
21.35	1869	22.59	18.98	1902	19.18
19.31	1870	16.24	18.28	1903	18.33
14.11	1871	27.53	20.59	1904	24.72
30.78	1872	22.42	23.45	1905	16.24
15.66	1873	18.56	20.42	1906	26.34
24.73	1874	22.52	26.17	1907	22.47
20.56	1875	22.63	17.35	1908	16.42
31.19	1876	23.54	25.57	1909	31.36
11.04	1877	11.93	19.52	1910	12.38
35.18	1878	33.26	25.49	1911	.....
24.44	1879	30.76	.....	1912	.....
26.66	1880	30.07	.....	1913	.....
29.86	1881	23.73	.....	1914	.....
16.14	1882	18.67	1915

Note { Seasonal is from July 1 to June 30.
 { Annual is from Jan. 1 to Dec. 31

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Average Monthly Rainfall—1849-1911

	July	Aug.	Sept.	Oct.	Nov.	Dec.
Averages	0.02	0.02	0.31	1.02	2.52	4.59
	Jan.	Feb.	Mar.	April	May	June
Averages	4.94	3.60	3.35	1.65	0.72	0.02

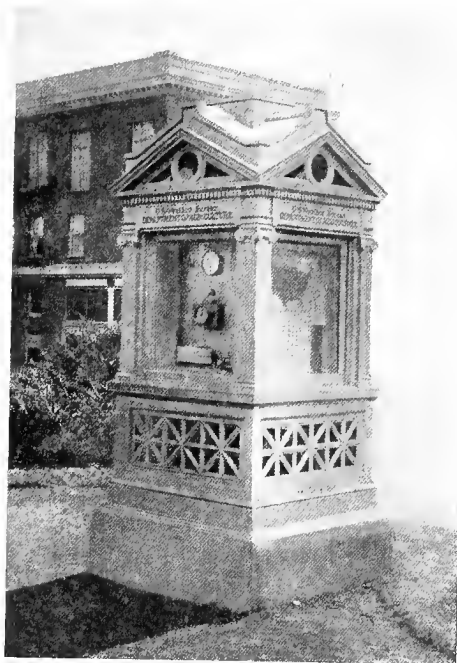
Average Seasonal Rainfall

22.90 inches.

Average Annual Rainfall

22.66 inches.





KIOSK

